5.5 ENHANCED DETENTION

Many regulatory agencies in the Coastal Zone require detention facilities for new development to manage the increased runoff volume associated with the increase in impervious cover. These facilities, sometimes with little or no modification to standard designs, can help create a sustainable stormwater drainage system. Excavation of detention ponds often brings the basin invert in contact with the water table. When this occurs, the basins with only a little additional excavation can take on the characteristics of either wetlands or wet ponds. The difference between the two is that wet ponds include substantially more open water. These two designs are described in detail below.

5.5.1. ENHANCED DETENTION WETLAND

Constructed wetlands are shallow pools with or without open water elements that create growing conditions suitable for marsh plants. Conventional stormwater wetlands are shallow manmade facilities supporting abundant vegetation and a robust microbial population. As constructed water quality facilities, stormwater wetlands should never be located within delineated natural wetlands areas. Significant potential exists for creative design and participation of an experienced wetland designer is highly recommended.

Constructed wetlands provide physical, chemical, and biological water quality treatment of stormwater runoff. Physical treatment occurs as a result of decreasing flow velocities in the wetland, and is present in the form of evaporation, sedimentation, adsorption, and/or filtration. Constructed wetlands offer natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal. Natural wetlands should not be used for stormwater treatment. A picture of a wetland detention system is presented in Figure 5-7.

Figure 5-7: Constructed wetland in Aransas County, Texas. (Photo courtesy of Danica Adams)

It is necessary to recognize that a fully functional wetland cannot be established spontaneously. Time is required for vegetation to establish and for nutrient retention and wildlife enhancement to function efficiently. Additionally, constructed wetlands should approximate natural situations as much as possible. Unnatural attributes, such as a rectangular shape or rigid channels, should be avoided. Because wetlands must have a source of flow, it is desirable that the water table is at or near the surface.

SELECTION CRITERIA

- Ideal when water table is relatively close to the ground surface
- Multiple benefits of passive recreation (e.g., bird watching, wildlife habitat)
- Never use natural wetlands, or wetlands provided as mitigation for impacts to natural wetlands, as a treatment device

LIMITATIONS

- When located in an area of high visibility, constructed wetlands may not appear especially attractive to residents
- May be infeasible to site or retrofit in dense urban areas

DETENTION WETLAND DESIGN GUIDANCE

1. ***Construction:*** The wet pond enhancement is created by over-excavating a portion of the detention basin. The material excavated, when suitable, can be used onsite to increase the finished floor elevations of any buildings constructed as part of development. The surface water elevation should be equal to the invert of the detention basin outlet.
2. ***Basin Inlets:*** Discharge to the facility should occur from as many inlets as possible to reduce concentrated flow. Energy dissipation should be provided at the inlet if the velocity of the flow is greater than 1 ft/s. Incorporation of low flow channels within the facility should be avoided as they concentrate runoff and reduce performance.
3. ***Facility Sizing:*** The excavated volume of the wetland area should be no smaller than the volume of runoff produced by a 1.5-inch rainfall event.
4. ***Pond Configuration:*** Stormwater constructed wetlands offer significant flexibility regarding pond configuration with the exception that short-circuiting of the facility must be avoided. Provision of irregular, multiple flow paths is desired. At least 25% of the basin should be an open water area at least 2-ft deep if the facility is exclusively designed as a shallow marsh. Added open-water area makes marsh space more aesthetically pleasing, and the combined water/wetland area creates a good habitat for waterfowl. The wetland zone should be 50 to 70% of the area and should be 6- to 12-inch deep.
5. ***Vegetation:*** A diverse, locally appropriate selection of wetland plant species is vital for all constructed wetlands. Wetland vegetation elements should be placed along the aquatic bench or in the shallow portions of the permanent pool. The optimal elevation for planting wetland vegetation is within 6 inches vertically of the normal pool elevation. Participation of a wetland designer or landscape architect familiar with local plants is highly recommended.
6. ***Outflow Structure:*** The outflow structure should be designed as required by local regulations to achieve necessary detention requirements.

5.5.2. ENHANCED DETENTION WET PONDS

The wet pond is a detention basin with a permanent volume of water incorporated into the design (Figure 5-8). Wet ponds are stormwater quality control facilities that maintain a permanent wet pool and a standing crop of emergent littoral vegetation. Wet ponds are often perceived as a positive aesthetic element in a community and offer significant opportunity for creative pond configuration and landscape design.

Biological processes occurring in the permanent pool aid in reducing the amount of soluble nutrients present in the water. Because they are designed with permanent pools, wet basins can also have recreational and aesthetic benefits. During storm events, runoff inflows displace part or all of the existing basin volume and are retained in the facility until the next storm event. Wet basins also help provide erosion protection for the receiving channel by limiting peak flows during larger storm events. Wet ponds may be feasible for watershed areas greater than 10 acres with a water table close to the land surface.

Figure 5-8: Picture of an enhanced detention wet pond. (Photo courtesy of Houston-Galveston Area Council)

SELECTION CRITERIA

- Multiple benefits of passive recreation (e.g., bird watching, wildlife habitat)
- Ideal for large, regional tributary areas
- Site area greater than 10 acres

LIMITATIONS

- There is concern about mosquitoes; however, aeration and/or stocking the pond with gambusia may eliminate this problem
- May be infeasible to site or retrofit in dense urban areas
- Potential hazard (drowning when side slopes are too steep or are bulk-headed)

DETENTION/WET POND DESIGN GUIDANCE

1. ***Construction:*** Wet pond enhancement is created by over-excavating a portion of the detention basin. The material excavated, when suitable, can be used onsite to increase the finished floor elevations of any buildings constructed as part of the development. The surface water elevation should be equal to the invert of the detention basin outlet.

2. ***Basin Inlets:*** Discharge to the facility should occur from as many inlets as possible to reduce concentrated flow. Incorporation of low flow channels within the facility should be avoided as they concentrate runoff and reduce performance.

3. ***Facility Sizing:*** The volume of the wet pond should be no smaller than the volume of runoff produced by a 1.5-inch rainfall event.

4. ***Pond Configuration:*** The wet basin can be configured as a two-stage facility with a sediment forebay and a main pool. Basins should be wedge-shaped, narrowest at the inlet and widest at the outlet when possible. The minimum length to width ratio should be 1.0. Higher ratios are recommended. A schematic of this design is presented in Figure 5-9.

5. ***Pond Side Slopes:*** Side slopes of the basin should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 should be stabilized with an appropriate slope stabilization practice.
6. ***Safety Considerations:*** Safety is provided either by fencing off the facility or by managing the contours of the pond to eliminate drop-offs and other hazards. Earthen side slopes should not exceed 3:1 (H:V). Landscaping can be used to impede access to the facility if desired. The primary spillway opening should not permit access by small children. Outfall pipes more than 48 inches in diameter should be fenced.
7. ***Depth of the Permanent Pool:*** The permanent pool should be no deeper than 8 feet and should average 4-6 feet deep.
8. ***Aeration:*** The performance and appearance of a wet pond may be improved by providing aeration of the permanent pool; however, this is not a requirement.
9. ***Vegetation:*** Aquatic plants should be allowed to grow along banks s to enhance water quality treatment and habitat functions and to discourage inappropriate recreational activities (e.g. swimming).

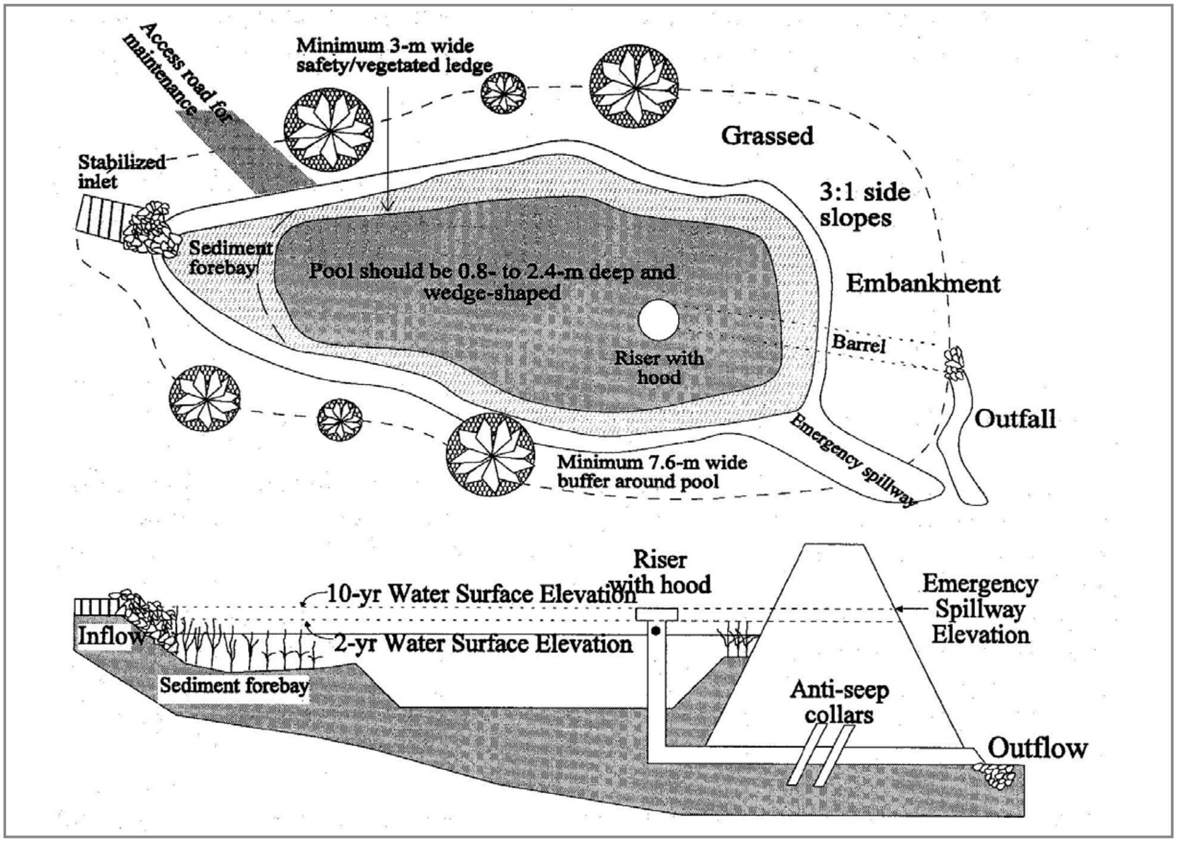

Figure 5-9: Schematic of a wet basin.

5.4.2. ENHANCED EXTENDED DETENTION

Extended detention basins capture and temporarily detain the water quality volume. They are intended to serve primarily as settling basins for the solids fraction, nutrients attached to solids, and as a means of limiting downstream erosion by managing stormwater.

- Extended detention basins may be constructed either online or offline.
- Extended detention basins are typically depressed basins that temporarily store stormwater runoff following a storm event and do not have a permanent water pool between storm events.

Water is controlled by means of a hydraulic control structure to restrict outlet discharge. Provided water quality benefits are the removal of sediment and buoyant materials. Furthermore, nutrients, heavy metals, toxic materials, and oxygen-demanding materials associated with these particles are also removed. Control of the maximum runoff rates serves to protect drainage channels below the device from erosion and to reduce downstream flooding. Refer to Figure 5-10 for a schematic of an extended detention basin.

One of the main advantages of extended detention basins is their adaptability; they can be used on areas with thin soils, high evaporation rates, low-soil infiltration rates, in limited space areas, and where groundwater is to be protected. Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.

Extended detention basins are generally best suited to drainage areas greater than three acres, since the outlet orifice becomes prone to clogging for small water quality volumes. Extended detention basins can also be combined with flood control detention facilities by providing additional storage above the water quality volume.

DESIGN GUIDELINES

1. ***Contributing Drainage Area:*** These areas should be less than 128 acres with no minimum drainage area.

2. ***Pre-treatment:*** A sediment forebay is designed to retain the bulk of the sediment entering the facility. This will simplify sediment removal and reduce overall basin maintenance. Refer to the design guidelines for sediment forebays in General Guidelines Item No. 7, where the forebay volume is equal to 25% of the water quality volume to retain the first flush runoff volume. To promote advanced treatment of the first flush volume, the forebay design relies on a berm and/or gabion within the basin to promote pollutant settling. Non-woven filter fabric with a 0.15 mm (U.S. Sieve Size 100) opening shall be placed on the gabion to enhance detention and facilitate maintenance. Rock riprap shall be placed on the downstream side to prevent scouring in the event flow passes over the gabion. Use guidance found in 3.2.4 and 3.2.

3. ***Basin Sizing:*** The BMP Volume is calculated by applying a factor of 1.05 to the Water Quality Volume (WQV) calculated per Chapter 2.3. The WQV is increased by a factor of 5% to accommodate for reduction in the available storage volume due to deposition of solids in the time between full-scale maintenance activities.

   BMP Volume = WQV * 1.05

   WQV = Required Water Quality Volume as calculated in Chapter 2.3 (cubic feet)

4. ***Basin Configuration:*** The extended detention basin is optimally designed to have a gradual expansion from the inlet toward the middle of the facility and a gradual contraction toward the basin outfall. The ratio of flow-path length to width from the inlet to the outlet should be at least 2:1 (L:W). Flow-path length is defined as the distance from the inlet to the outlet as measured at the surface. Width is defined as the mean width of the basin. Higher length-to-width ratios are recommended. Outlets should be placed to maximize the flow-path through the facility. The basin should maintain a longitudinal slope between 1.0 – 5.0% with a lateral slope between 1.0 – 1.5%.

5. ***Basin Depth:*** The water depth in the basin when full should be no greater than 8 feet.

6. ***Basin Outlet:*** The facility's drawdown time should be regulated by an orifice plate located downstream of the primary outflow opening. The outflow structure should be sized to allow for complete drawdown of water quality volume within 48 to 72 hours. In addition, the outlet shall be configured to provide at least 12- hour detention for 0.5 inches of runoff from the total effective impervious cover. The minimum orifice diameter is 1-inch. Non woven filter fabric with a minimum opening of 0.15 mm (U.S. Sieve Size 100) shall be wrapped around the riser to enhance detention. Risers should be double-wrapped with filter fabric until the contributing drainage area is vegetated and stabilized. Outflow structures must have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The following equation can be used to determine the required orifice size:

$$A_O = \frac{0.001 BMP\_Vol.}{C\sqrt{2gH_{avg}}}$$

A_O = maximum orifice area (square inches)
$BMP\ Vol.$ = required basin volume as calculated above (cubic feet)
C = orifice coefficient (Typical. 0.62)
g = acceleration of gravity (32.2 ft/s^2)
H_{avg} = H_T/2, average hydraulic head (ft)
H_T = total hydraulic head determined from difference between the WQ elev. and the center of orifice

7. ***Basin Soils:*** To enhance infiltration and water storage within the basin, topsoil must be placed on the basin floor after excavated bottom is scarified to a depth of 2 to 3 inches to improve drainage. Topsoil must be 6 to 8 inches deep with a soil mixture of 30-40% sand or granite sand, 60-70% topsoil, and 5-10% compost or peat to aid in water retention and promote vegetation growth. Soil blend must have clay content less than 20% and be free of stones, stumps, roots or other similar objects larger than one (1) inch. If on-site soils do not meet these specifications, topsoil per the above specs must be added. Sandy loam is not an approved soil and caliche is not considered a soil.

8. ***Vegetation:*** To enhance appearance and function, trees, shrubs, and additional forb vegetation are recommended along with Bermuda grass coverage (strongly recommend sod). Refer to bioretention basin vegetation requirements (4.2.2 (10)) for guidance. Muhly grass can be used to aid in spreading flow and concealing the riser pipe and mid-basin gabion. Trees and shrubs can effectively screen other structural aspects while also aiding in evapotranspiration and basin floor drying.

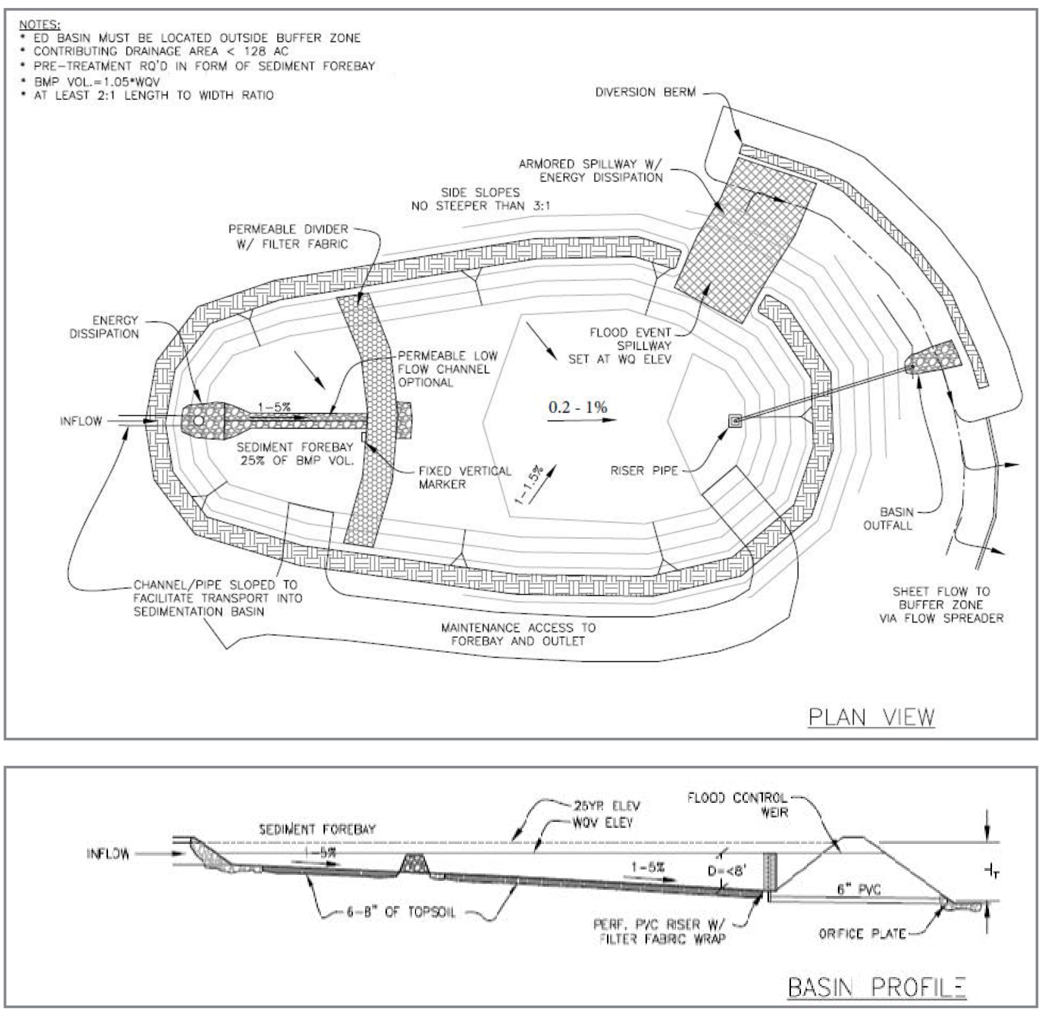

Figure 5-10: Schematic of an Enhanced Extended Detention Basin

5.5.4. RECOMMENDED MAINTENANCE

Extended detention basins capture and temporarily detain the water quality volume. They are intended to serve primarily as settling basins for the solids fraction, nutrients attached to solids, and as a means of limiting downstream erosion by managing stormwater.

ROUTINE MAINTENANCE

- ***Mowing.*** The side-slopes, embankment, and emergency spillway of the basin should be mowed at least twice a year to prevent woody growth and control weeds.

- ***Inspections.*** Wet basins should be inspected at least twice a year to evaluate facility operation. When possible, inspections should be conducted during wet weather to determine if the basin is functioning properly. The embankment should be checked for subsidence, erosion, leakage, cracking, and tree growth. The condition of the emergency spillway should also be evaluated. The inlet, barrel, and outlet should be inspected for clogging. The adequacy of upstream and downstream channel erosion protection measures should be checked. Stability of the side slopes should be tested. Any modifications to the basin structure and contributing watershed should also be evaluated.

  During semi-annual inspections, prepare and update maintenance checklists and replace any dead or displaced vegetation. Replanting various species of wetland vegetation may be required until a viable mix of species is established. Cracks, voids, and undermining should be patched/filled to prevent additional structural damage. Trees and root systems should be removed to prevent growth in cracks and joints that can cause structural damage. Inspections should be carried out with as-built pond plans in hand.

- ***Debris and Litter Removal.*** Debris and litter should be removed from the surface of the basin. Particular attention should be paid to floatable debris around the riser, and the outlet should be checked for possible clogging.

- ***Erosion Control.*** The basin side slopes, emergency spillway, and embankment all may periodically suffer from slumping and erosion. Corrective measures such as regrading and revegetation may be necessary. Similarly, riprap protecting the channel near the outlet may need to be repaired or replaced.

- ***Nuisance Control.*** Most public agencies surveyed indicate that control of insects, weeds, odors, and algae is needed in some ponds. If the ponds are properly sized and vegetated, these problems should be rare in wet ponds with the exception of extremely dry weather conditions. Twice a year, the facility should be evaluated in terms of nuisance control (insects, weeds, odors, algae, etc.). Biological control of algae and mosquitoes using fish such as fathead minnows is preferable to chemical applications.

NON-ROUTINE MAINTENANCE

- ***Structural Repairs and Replacement.*** Eventually, the various inlet/outlet and riser works in the wet basin will deteriorate and must be replaced. Some public works experts have estimated that corrugated metal pipe (CMP) has a useful life of about 25 years, while concrete barrels and risers may last 50 to 75 years. The actual life depends on the type of soil, pH of runoff, and other factors. Polyvinyl chloride (PVC) pipe is a corrosion resistant alternative to metal and concrete pipes. Local experience typically determines which materials are best suited to the site conditions. Leakage or seepage of water through the embankment can be avoided if the embankment has been constructed of impermeable material, has been compacted, and if anti-seep collars are used around the barrel. Correction of these design flaws is difficult.

- ***Sediment Removal.*** Wet ponds will eventually accumulate enough sediment to significantly reduce storage capacity of the permanent pool. As might be expected, the accumulated sediment can reduce both the appearance and pollutant removal performance of the pond. Sediment accumulated in the sediment forebay area should be removed from the facility every two years to prevent accumulation in the permanent pool. Dredging of the permanent pool should occur at least every 20 years, or when accumulation of sediment impairs functioning of the outlet structure.

- ***Harvesting.*** If vegetation is present on the fringes or in the pond, it can be periodically harvested and the clippings removed to provide export of nutrients and to prevent the basin from filling with decaying organic matter. Clippings may be composted onsite, away from the wet pond, or at an off-site composting facility.